I. C. 6469 JULY, 1931

DEPARTMENT OF COMMERCE

UNITED STATES BUREAU OF MINES
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PROGRESS IN METAL-MINE VENTILATION IN 1930[1]

By D. Harrington[2]

Along with other phases of mining, the ventilation of metal mines has been affected by the business depression of 1930. As might be expected, some of the results are favorable, and some are distinctly disadvantageous to progress. Probably the worst effect of the recession of mining activity is that, as usual, one of the first departments of almost any industrial establishment (and this is especially true of mining) to be curtailed is that which concerns what might be called welfare work, such as safety, health, etc., and ventilation: in consequence, a number of men who were employed mainly on ventilation work in metal mines are now out of employment and their former duties either are being handled by others as only part of a crowded routine or are being allowed to lapse. On the bright side of the picture is the following paragraph from a letter by the ventilation and safety engineer of the United Verde Copper Co., Jerome, Ariz., indicating that money and effort expended on ventilation during "flush" times give results which aid in money savings when depression comes:

> The desirability of absolute control over the ventilation system has again been demonstrated at this mine. Under full operation we have been using approximately 500 hp. to drive our big fan. Under curtailed operations we naturally do not require as much air, so by sending the air only where needed and airing out all other places periodically to keep timber, etc., in good condition we have been able to economize in the quantity of air required. The fan speed has been reduced and the power dropped to 300 hp., thus effecting a material saving in the power bill, and still maintaining an efficient ventilating system."

MINE GASES

Early in July, 1930, an outburst of carbon dioxide in a coal mine in Silesia killed more than 150 persons, some of whom were hurled to death by explosive violence, although most of the deaths were from asphyxiation due to very quick flooding of the workings by CO_2 gas. While this was in a coal mine and there have been a number of other similar disasters in coal mines in southern France as well as in Silesia, there is no guarantee that metal mines may not also experience this type of disaster. In this connection the following item from the Salt Lake Mining Review of June 15, 1930, indicates that CO_2 under heavy pressure is found in the United States also:

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[1] - The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6469."
Presented before the Annual Meeting of the American Institute of Mining and Metallurgical Engineers, New York, N. Y., February, 1931.

[2] - Chief Engineer, Safety Division, U. S. Bureau of Mines.

> Last week marked the birth of an entirely new and important industry in the State of Utah, when the gas well, which has been drilled on the Farnham structure, located about 15 miles east of Price, blew-in June 4, with some million and a half feet of carbon dioxide gas a day.
>
> On June 3 the bit passed through the cap rock and entered the producing sands. The gas, which is 114 degrees below zero, froze the water in the well. Drilling operations were suspended to build up enough pressure to melt the ice and on Wednesday, June 4, the well blew-in, shooting over the derrick in a spectacular sight. By using a smaller drill and working five minutes at a time, the well will be drilled farther into the sand for an estimated production of twelve million feet a day.
>
> Carbon dioxide gas was first developed on the Farnham structure by the Utah Oil Refining Company in 1923. The well had a production of approximately 20,000,000 cubic feet per day and a 900 pound rock pressure. At that time there was no market for such gas and the well was abandoned and finally lost.
>
> Providing sufficient gas pressure is developed in the present well, the Carbon Dioxide & Chemical Co. plans to begin immediate construction on a plant to manufacture "dry ice." The plant will cost approximately $150,000, it is stated, and will be built by the Frick Machine Co. of Waynesboro, Pa.
>
> This will be the first plant of its kind in the world, using natural carbon dioxide gas. Other plants of similar structure are now in operation, but use gas manufactured from coal.

Although there was but one metal-mine fire with loss of five or more lives during the year, this being the one at the Glenn mine in California in July with five deaths, all from asphyxiation by fumes chiefly from burning surface buildings, nevertheless the subject of mine fires has received considerable attention. Another fire, also in surface buildings, at the Homestake mine in South Dakota in July, 1930, resulted in two deaths; in this case it is probable that control of direction of air flow, allowing prompt reversal of direction of air in the shaft, prevented entrance of the fire into the mine with possibly heavier loss of life. There was also a fire in a Michigan mine with one death, and here again the use of mechanical ventilation aided in the handling of the fire with minimum loss of time, property, and probably life.

During the year the American Standards Association under sponsorship of the National Fire Protection Association and the American Mining Congress adopted a code on Fire Fighting Equipment in Metal Mines, as recommended Practice for Fire-Fighting Equipment, Preventive Measures, Fire Signals and Fire-Fighting Personnel; among its provisions are the following:

> 2000. At all levels, close to shafts and near all other entrances to the mine, fire doors should be provided. They can be so

arranged that all may be simultaneously closed from any shaft station or entrance or from surface. Ventilation doors should not be regarded as substitute for fire doors.

2004. In mines with natural ventilation only, a fan large enough to adequately ventilate the mine should be used. This fan should be actually used at least once a month to test its satisfactory operation.

2005. Proper ventilation should be established as the first means of reducing underground temperatures.

2006. There should be proper control and understanding of air currents through all workings.

2011. Air leakage through doors tends to interfere with proper ventilation control, and should be eliminated by proper door construction.

2012. In mines of great horizontal extent, air splits should be established to eliminate possibility of fire at one point spreading to or filling all workings with smoke.

2013. Portable fans should be available and of sufficient size to admit of ventilation control in drifts when entry to fires is necessary. (Brattices may be necessary to prevent surge or recirculation of air past portable fans.)

2016. Air control should be positive and, when forced draft is in use, doors should be provided to eliminate natural draft if necessary.

2017. Mine air doors should be marked with signs reading "Open" and "Closed."

2018. If reversible fan installations exist, a thorough knowledge of the effect of reversing air currents should be obtained by experiment, and such reversible control should be possible to only those who are thoroughly familiar with same, and then only after consultation. Positive orders should be posted governing the use of such equipment.

2019. Level bosses should be made thoroughly conversant with air currents throughout their workings, and maps should be available in the bosses' headquarters indicating air currents through various openings. Such maps should be up to date and available for prompt use at all times.

2020. A thorough knowledge of ventilation control should be vested in a sufficient number of responsible officials to insure the presence of some of them in the event of fire.

2022. In case of forced draft ventilation, some one exit should be available which can be maintained free of smoke.

2023. Safety chambers should be established where there is probability of retreat being cut off.

2024. Smoking in mines is prohibited.

2025. A means should be provided to prevent fire and smoke from surface fires entering workings.

An excellent discussion of the above "code" is contained in a five-page illustrated article on Mine-Fire Prevention and Fighting, which appeared in the August, 1930, issue of The Mining Congress Journal. The author of this discussion takes up numerous conditions which enter into metal-mine fires, and while he recognizes the dangers of smoking and open lights, apparently can not "shake off" the metal-mining man's curious and inexplicable aversion to the adoption of the up-to-date portable electric lamp for miners which is now so successfully used in coal mines.

The following item appeared in the Engineering and Mining Journal of 30 years ago - the issue of July 10, 1930:

> The Comstock Lode (discovered in 1859) was the scene of considerable excitement in the spring of 1869, when fire broke out in the Kentuck mine, at Gold Hill, Nev., and, spreading to the Yellow Jacket and Crown Point, was the cause of the death of 36 men. Many weeks passed before it was put out. The deaths were attributable to the same factor all too common today--lack of an emergency shaft and underground connections, with no prearranged ventilation system, in case of fire.

It is significant that 30 years ago the caustic comment was made that "the deaths were attributable to the same factor, all too common today-lack of an emergency shaft and underground connections, with no prearranged ventilation system, in case of fire." Unfortunately what applied in 1869 and what apparently applied 30 years ago still applies in many many metal mines in the United States, at least.

In a short article on Fires in Witwatersrand Mines in the May 24, 1930, issue of The South African Engineering and Mining Journal the following paragraph occurs:

> It is doubtful if there is a mine on the Witwatersrand, which has been winning ore for, say, the last 20 years, which has not also had the experience of a fire underground. In some cases these fires have been of small scope and severity, but in others the results have been serious, in both loss of life and damage to property. It will be recalled, in the case of the Ferreira Deep Mine fire of some years ago, that a station collapsed, resulting in the loss of 14 lives, and the damage done must have cost the company thousands of pounds.

A few causes of fire in the metal mines of South Africa are given and a few precautions suggested, although neither the causes nor the precautions would be at all adequate if applied to metal mines of the United States.

TUNNEL VENTILATION

Ventilation, while tunnels are being driven and when vehicular and similar tunnels are in use, has been given much attention in recent years with especial reference to the Holland Tunnels in New York, the Liberty Tunnels in Pittsburgh, the new Detroit-Windsor Tunnel, and possibly others. New problems arise or old problems recur with variations. On June 8, 1930, an explosion, with seven deaths resulting in the Upper Alameda Tunnel being driven for water purposes by the City of San Francisco, near Livermore, Calif., again called attention to the presence of methane in tunnels in the coast-range mountains of California, especially in the region more or less adjacent to San Francisco. When this explosion was followed on July 17, 1930, by another explosion, causing 12 deaths, in the Mitchell Shaft Tunnel, one of the Hetch Hetchy Tunnels of the City of San Francisco, there was a demand for action, and the Governor of California almost immediately appointed a committee of five to investigate and report; the demand for the appointment of this committee was accentuated by the fact that on July 12 there was a fire which caused five deaths at the Glen mine in Placer County, Calif., and the committee's work was broadened to include not only tunneling but mining operations. Before the committee could meet, some drastic regulations in connection with the driving of tunnels in gassy strata were drafted by the Industrial Accident Commission of California in cooperation with an engineer of the United States Bureau of Mines who was familiar with methane gas and how to handle it; these regulations were promulgated by the commission as applicable to the tunnels of the Hetch Hetchy project, which were known to be gassy. These regulations are so unusual that they are quoted in full; the City of San Francisco as the operator in the driving of the tunnels accepted the regulations, though later there were some minor modifications.

Exhibit A

San Francisco, Calif.
July 24, 1930.

Mr. M. M. O'Shaughnessy,
Chief Engineer, City and County of San Francisco,
City Hall,
San Francisco, California.

Dear Mr. O'Shaughnessy:

As the result of conferences between you, members of your staff, the United States Bureau of Mines, and members of the Industrial Accident Commission, the Industrial Accident Commission hereby adopts the following as special safety orders applicable to the workings in the Coast Range Division of the Hetch Hetchy Water Supply.

1. Ventilation.

(a) An exhaust system of ventilation shall be provided in all workings, auxiliary blowers shall be provided to force fresh air from the fresh air supply to the face of the workings.

(b) Means shall be provided for removing standing gas in the roof of the tunnel, either by means of fresh air jets or baffles. Instructions shall be posted at the collar of each shaft, and in each fan house to immediately reverse the fans so that they will be blowing instead of exhausting in case of a fire at the head frame. If there is a fire only around the fan house and fresh air can still go down the shaft, the fans shall be continued as suction fans.

If there is a fire at the fan house, the fans must be used as suction fans only.

2. All persons underground shall be equipped with electric cap lamps or other electric lights approved by the U. S. Bureau of Mines. These lamps or lights shall be given the required attention that will keep all of them in a safe condition.

3. An occasional search for matches and smokers' articles shall be made.

4. All electrical equipment underground, except as noted below, shall be of a type classified as permissible by the United States Bureau of Mines. Exceptions: Pumping motors, induction type, as at present used at the bottom of the shaft; and electric lighting in the shaft, at the bottom of this shaft, and in the crosscut. All electric lights shall be of the type submitted to the U. S. Bureau of Mines, which consists of a special socket equipped with a vapor proof globe and a heavily reinforced guard.

The present motors used on the pump at the bottom of the shaft may be continued as long as they are in fresh air in which there is no methane.

The electrical loaders and electrical motors at Irvington may be continued until such time as methane is found.

Alameda Creek (West). The electric loaders and the electric motors may be continued until methane is found.

Alameda Creek (East). The present electric loader and motor may be used until methane is found. As this heading is going toward Indian Creek Shaft, great care must be exercised and immediately upon the discovery of any gas, all electrical equipment must be discontinued until permissible equipment can be secured.

Thomas Shaft (East), The electric motor in this heading is to be immediately replaced by an air loader. The electric motor in this heading may be used in fresh air, if it does not go closer than 500 feet to the face.

Tesla Portal. The electric motor in this heading may be used until gas is found, if it does not go within 500 feet of the face.

All of the above are with the understanding that should gas be found by an approved electrical detector, work will immediately be stopped insofar as the electrical equipment is concerned or until investigation by the Industrial Accident Commission has been made, and new orders issued covering the matter. It is also understood that the exception mentioned in the Irvington, Alameda Creek, and Tesla workings are based on the replacement of the present electrical equipment at the earliest possible moment by permissible equipment.

5. All electrical equipment, other than that specified above, shall be removed from the workings. This includes the present lighting system and the lighting transformer.

6. All water pumping equipment in the tunnels shall be driven by compressed air.

7. All blasting shall be done when men are out of the mines.

Exception: Plug holes may be shot if done with instantaneous detonators fired by a magneto with the hole properly stemmed, the minimum amount of explosive used, and the men removed to a safe distance.

It is recommended that permissible powder be used. If feasible, all plug shots shall be fired by the fire boss when the men are out of the mine.

8. Magnetically locked permissible flame safety lamps shall be used and shall not be left unattended.

9. All fire bosses shall be certified by the Industrial Accident Commission.

10. An anemometer shall be provided and readings shall be taken, at least weekly, and recorded of the air current in all workings.

11. Should more than 0.5 of 1% of methane be found at any time in the intake fresh air, all men must be taken to the surface until ventilation has been restored and the methane contents reduced to less than 0.5 of 1%.

12. There shall be one man, known as a fire boss, equipped with an approved electrical detector at each shaft, and if necessary at each heading. In order that there may be a complete record of the gas, detailed report shall be required from the man using the detector. These reports are to be kept on file. He shall spend his entire time testing the air and shall advise the boss of the condition and if he deems necessary, shall instruct the boss to take the men out of the mine or do whatever may be necessary under the circumstance.

13. Immediately before shooting, the fire boss shall test the air at the point of shooting and if more than 0.5 of 1% of methane is found no shooting shall be done until there is less than 0.5 of 1% of methane at that point. After blasting no one except the fire boss shall enter the vicinity of the blast until he has found that there is less than 0.5 of 1% of methane.

14. If gas feeders are found at any time, the fire boss shall be immediately notified, and take whatever action is necessary.

15. When ventilation ceases for any reason, the men must be removed to the surface and they must not return until the workings are found to be free of methane as described above, which is a maximum of 0.5 of 1%.

16. It shall be the duty of the shift boss or the man in charge of the re-timbering operation or other work underground to use a flame safety lamp and make tests with the lamp at least once each hour, and should his lamp show the presence of methane, the men must be removed until the place has been made free from gas. A record of these tests shall be kept.

17. No open lights, cigarette lighters, matches, or smoking materials shall be allowed underground. A large notice to this effect shall be posted in plain view at each head frame and portal.

18. There shall be a carbon dioxide fire extinguisher at each motor or motor-generator set underground.

19. All electrical work shall be performed by a qualified person. Electrical Safety Order 701-1 (g).

20. All fire hazards both underground and on the surface shall be eliminated as far as possible, with special attention to the fire hazard at the collar and bottom of the shaft and entrances to the tunnel.

21. Owing to the conditions which exist at this project, a very rigid discipline must be maintained at all times.

22. Whenever tunnel operations are not continuously prosecuted, the workings must be tested by an electrical detector and found free of gas before men are allowed to return to work.

23. A detailed plan must be worked out which will provide for the handling of any emergency in any one of the workings or headings. One man shall be delegated to take entire charge of all safety work.

This plan shall include the following:

(a) Provisions for notification from underground to the surface of any hazardous conditions.

(b) Notification to the superintendent.

(c) Notification to headquarters at Livermore.

(d) Livermore headquarters shall be available 24 hours a day.

(e) Livermore to assemble material, supplies and men to proceed to the scene of the trouble.

(f) The mine rescue equipment shall be kept at Livermore in condition for immediate use at all times.

(g) Livermore shall notify all locations with instructions to act.

(h) Doctor, hospital and ambulance service shall be secured.

(i) Livermore shall notify Fred L. Lowell, 3932 Lakeshore Ave., Oakland, Telephone: Glencourt 3837, or C. H. Fry, 2714 Garber, Berkeley, Telephone: Thornwall 5648, or during office hours, the Industrial Accident Commission, State Building, San Francisco, Telephone: Underhill 8700.

(j) The regulations of the U. S. Bureau of Mines as shown in their pamphlet: "Rescue and Recovery Operations in Mines after Fires and Explosions" shall be used as a guide in this work.

(k) All men who might be called upon in case of an emergency shall be thoroughly instructed in the use and the limitations of the all-service gas masks.

(l) There shall be a first-aid dressing station at the bottom of each shaft and at the portal of each tunnel; this shall be kept in charge of some competent person.

(m) Mine rescue training shall be continued every month. Only those men who pass a physical examination shall be allowed to take the training and all such men shall be re-examined at periods of not more than six months. The following men, if physically fit, should take this training: Superintendents foremen, shift bosses, electricians, motormen, engineering staff and designated miners.

It is understood that there is to be a further conference on the morning of Saturday, July 28th, 1930, as to some of the details of the orders as agreed upon.

(SIGNED) WILL J. FRENCH
(SIGNED) DELGER TROWBRIDGE
Members, Industrial Accident Commission.

cc — Board of Supervisors, City Hall, San Francisco
T. A. Reardon, President, Board of Public Works,
251 City Hall, SF
(Received at City Engineer's office 10:53 A.M., July 25, 1930.)

In its report to the Governor of California the committee of five approved the above regulations and called attention to the fact that not only the Hetch Hetchy Tunnels but numerous railroad, vehicular, water, and other tunnels driven in the coast-range mountains of California, as well as some metal mines in these mountains, have had fires or explosions, or both, due to ignitions of methane. The following paragraphs from the report give some interesting data on these previous methane fires and explosions.

> The explosion in the upper Alameda Creek Tunnel on June 8th, with seven deaths, followed by that in the Mitchell Tunnel of July 17th, with 12 fatalities, brings forcibly to attention the abnormal hazard of explosive gas (methane) encountered in driving tunnels in the coast range hills and mountains of certain parts of California. Although the finding of explosive gas in prosecuting operations underground, except in certain sections of California, is relatively unusual, yet there have been a number of previous disasters in California tunnel driving, a partial list of them being as follows: between 1870 and 1880, 13 Chinese were killed in a methane explosion in a railroad tunnel near Santa Cruz; in 1918, an explosion of methane occurred in a water tunnel in Marin County; on June 26, 1918, a methane explosion which killed five men occurred in the Wild Cat Canon Tunnel, near Richmond; in June, 1927, a methane explosion in the Claremont Tunnel, Oakland, burned 11 men.
>
> In addition to the Mitchell Tunnel explosion of July 17, with resultant 12 deaths, there have been a number of other cases of ignitions or explosions of methane in the tunnels of the Hetch Hetchy project, a partial list being as follows: On June 5, 1928, an explosion of methane, and subsequent fire, occurred in the Mocho shaft, no person being injured; another gas explosion occurred in this shaft on August 13, 1928, fortunately without injury to workers; on March 13, 1929, there was an explosion of gas in the Mitchell shaft, two men being burned and one killed by a falling timber; on June 8, 1929, an explosion of methane in the Mocho shaft did not injure anyone; on September 9, 1929, in the Mocho shaft, 3 men were burned by gas; on September 18, 1929, an explosion of methane with subsequent fire occurred in the Tesla Tunnel, no one being injured; on October 22, 1929, an explosion of methane seriously burned three men at the Indian Creek shaft.

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It thus appears that there have been at least seven explosions and several fires due to methane ignitions in the Hetch Hetchy Tunnels.

The above instances of explosions and fires from explosive gas in California tunnels unfortunately do not exhaust the cases in which explosive gas has caused accidents in underground workings in California. It is stated that up to 1925, at least 20 persons had been killed in explosions of gas in the quicksilver mines of the State. On January 7, 1928, explosive gas was ignited by a miner's open light in the Oceanic Quicksilver mine in San Luis Obispo County with resultant death of one man and severe burns to seven others. On February 19, 1926, another gas explosion occurred in this mine with ignition probably due to arc from electric light wires, there being two men killed and one severely burned.

The report of the committee of five also recommended, among other things, that a study be made of the region of California in which methane gas is likely to occur, that the region be designated as gassy, and that the requirement be made that any underground operations be conducted with certain extra precautions in accordance with judgment of the Industrial Accident Commission, the probable precautions being as follows:

When in any underground workings in California, explosive gas in excess of 25/100ths of 1 per cent is found, the workings should be designated as gassy and these workings should be placed under regulations similar to those embodied in the July 24, 1930, Orders of the Industrial Accident Commission as applied to the coast-range tunnels of the Hetch Hetchy project. If a portion of California should be designated as gassy as a result of the study proposed by the report of this Committee of five, the requirements for gassy mines should in the future be put into effect upon starting of any underground operations in such gassy district or districts. The requirements in connection with these gassy workings might include, among other provisions, the use of closed lights and exclusion of open lights and smoking (this would require the use of permissible electric cap lamps and permissible devices for detecting explosive gas); use of permissible explosives and of permissible electrical equipment; shooting to be done electrically from the surface with all persons out of the underground workings, provision to be taken that the electrical current shall be in the power lines but a fraction of a second when blasting; efficient mechanical ventilation should be used, the ventilation to be such that the main exit for persons will be in intake or fresh air, with free use of flexible tubing methods forcing ample volumes of fresh air to the face regions; the main hoisting shaft should be concreted or otherwise fire proofed, and where the length of underground tunnel is over 500 feet, the shafts and/or tunnels should be driven in pairs with connections at proper intervals in order to provide effective means for air circulation; fire bosses, preferably with coal mine experience, with State certificates, should be required, as in coal mine practice, and their inspection and other duties definitely stated; the superintendent, foreman shift bosses, fire bosses, shot-firers, and safety men in an underground operation designated as gassy should have State certificate as being qualified to operate gassy workings with reasonable safety; there should also be required, within a radius of 25 miles or within one hour's reach by automobile or rail, and reached by telephone and good roads, a well equipped mine rescue station with at least five, or preferably ten, sets of up-to-date approved type oxygen breathing apparatus (with pump and other accessories), in charge of a responsible safety man, and with at least ten men well trained in the use of these apparatus; rigid inspections and written reports by the State should be made at least every three months. There should also be a definite and adequate penalty for the taking of matches or smoking material into any underground workings designated as gassy, and a rigid search should be made for matches, etc., at least once a week. Under no circumstances should open type electric wiring or incandescent lights be used in workings designated as gassy. The ventilation system should be so arranged that controlled air circulation is continuous throughout the entire operation at all times during every day.

Numerous suggestions were made to the Industrial Accident Commission in form of an appendix to the report of the Governor's Commission, those dealing with mine or tunnel ventilation being as follows:

In future tunneling in the "gassy" strata in California, consideration should be given the advisability of the following procedure. The tunnels as well as the auxiliary shafts used in connection with the tunnel operations should be driven in pairs in order to allow of providing safe efficient circulation of air and also safe exits for underground workers; at least one shaft the one used for hoisting, should be concreted or otherwise fire proofed throughout, and all tunnel portals should be concreted or otherwise fire proofed at least 500 feet from the surface.

In every underground operation, there should be in every underground drift or tunnel opening from every main shaft, tunnel or incline which gives ingress or egress to and from such underground workings, a door or set of doors so placed that air flow from or to such shaft, tunnel or incline can be cut off at any or all tunnel or drift openings by the closing of these doors. Preferably these doors should be located in the auxiliary drifts or tunnels, approximately 100 feet from the above mentioned main shaft, tunnel or incline.

Inflammable material or structures should be kept at least 100 feet from the mouth or portal of shafts, slopes, or tunnels leading underground; if not feasible to remove such structures, they should be made fire-proof or fire retardant by guniting or other method.

The mouth or portal of every shaft, slope or tunnel should be provided with suitable fire doors such that in case of fire on the surface neither gases nor flames shall enter the underground workings,

Every underground operation having electricity underground should have at least a monthly inspection and written report by competent person on the condition of underground electrical wiring and other installations, with especial reference to hazards from possible fires and contact electrocutions. Copy of this report should be kept on file at the mine or tunnel.

Electrical cables transmitting current into mines should be of high-class, well-insulated type and so placed as to give minimum hazard of igniting timber in shafts, slopes, or tunnels.

When a mine employing 10 or more men underground is reached by a shaft or shafts of inclination over 45 degrees and depth over 300 feet, there should be provided at least two places of exit separated from each other at all points by 50 or more feet and there should be hoisting equipment in at least 2 such shafts, such that in case of fire or other blocking of egress from the main hoisting shaft, those underground can be hoisted from all parts of the mine through the other shaft. Preferably the down cast shaft should be concreted or otherwise made fire proof or at least fire retardant.

The main hoisting shaft in every case should be downcast, and preferably mechanical ventilation should be provided to insure that downcast ventilation of the main shaft is maintained. The fan should preferably be on the surface in fireproof housing, and so installed that in case of emergency direction of air flow may be reversed. If the mine works steadily, the fan should be kept in continuous operation.

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It would add materially to underground safety if smoking were prohibited in and around underground workings, as many disastrous metal mine and tunnel fires have been caused by smoking.

The trolley wire used in the trolley locomotive haulage system has caused many fires and has also caused "electrocution" of many underground workers. When at all feasible, trolley locomotives should be superseded by those of storage battery type, preferably those given U. S. Bureau of Mines permissibility. Where the trolley system is used, the wires should be adequately guarded throughout every foot of their length, the track should be kept adequately bonded, the wires should not be allowed to touch timber or other flammable material, and current should be "cut out" of the trolley system when trolley haulage is not in actual use.

Where 10 or more men are employed underground on any one shift, every person in charge of underground operation as superintendent, foreman, shift boss, or safety man, should by all means be required to have certificate of competency from the State, indicating that he is qualified to safeguard the men under his jurisdiction. Preferably these certificates should expire every 5 years and be renewable only upon taking a rigid written and oral examination.

All underground workings should have ample fire fighting equipment and definite thought should be given to possibilities in connection with occurrence of fire. No underground operation is so small or so large as to be able to afford to fail to make definite plans towards prevention of fire as well as for fighting fire should one occur.

Every underground operation in California should file with the Industrial Accident Commission certified map, or print of a map, of its underground workings, and this map should be brought up to date as of Dec. 31 of each year. The map should be held in the confidential files of the Industrial Accident Commission and be used only in connection with safety inspections and report work.

In view of the fact that intensive supervision is now considered as probably the most direct and effective means of accomplishing safety results in and around the mining and allied industries, it is suggested that there be an always present competent supervisory official for approximately each 25 persons employed, these supervisory officials to visit and if necessary instruct every employee under their supervision at least twice during every working shift.

AIR CONDITIONING

During the year the technical press had the usual number of articles on various phases of "air conditioning." A very short report in the June 23, 1930, issue of the Engineering and Mining Journal under the caption "Deepest Mine in America Adopts Air Conditioning" gives a brief description of a Carrier air-conditioning plant recently tested in the Morro Velho mine, Brazil. It is stated that although the rock temperatures in the lowest parts of the mine are 130°F., "a 90° temperature may now be maintained at the bottom of the mine," and that "A feature of the new equipment is the absence of hazard factors. Comfortable working conditions result. The drying process, a part of the Carrier system, reduces the excessive humidity of the air normally characteristic of deep mines. The installation is operated by two 125-h.p. motors."

As usual, the year has been productive of a relatively large number of articles in the technical press concerning ventilation in the metal mines of South Africa. The Empire Mining Congress number of the South African Mining and Engineering Journal, April, 1930,

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includes voluminous abstracts from papers dealing with numerous phases of South African mine ventilation as follows:

> Witwatersrand Mine Ventilation — P. J. Rees.
> Ventilation System and Conditions at the Crown Mines, Ltd. — A. J. Walton.
>
> The Ventilation System of the Government Gold-Mining Areas. — R. A. H. Flugge-de-Smidt.
>
> Temperatures and Ventilation in Deep-Level Mines of the Witwatersrand. — E. C. Ranson.
> A Review of the Hygiene Organization of the Witwatersrand Gold Mines. — A. J. Orenstein.
>
> First-Aid Organization on the Witwatersrand Gold Mines. — H. T. H. Butt.
> Miners' Phthisis on the Rand. — Dr. L. G. Irvine, Dr. A. Mavrogordato.
> A Short Description of the Operations of the Organizations through which the Native Labour Employed by the Witwatersrand Gold Mines is Obtained. — W. Gemmill.
>
> The Estimation of Dust in Mine Air. — J. Boyd.
> The Explosives Industry in South Africa with special reference to Rand Mining. — John Christie.

The paper on The Ventilation System of the Government Gold-Mining Areas, by R. A. H. Flugge-de-Smidt, appeared in the Canadian Mining Review and had much information of value concerning South African ventilation practice. Herewith are some interesting paragraphs taken from the paper:

> A tandem compound engine of 1,500 hp. drives the fan, which is designed to pass 900,000 cubic feet of air per minute at a water gauge of 7 inches. At present the fan is operating at four-fifths of its full speed, and is handling approximately 800,000 cubic feet of air per minute (measured in the fan drift), the water gauge being 4.5 inches.
>
> Two timbermen and eight natives are employed solely for the construction and maintenance of doors and stoppings.
>
> Generally speaking, the policy on Government Areas is to concentrate as much of the cold downcast air as possible at the lowest points in the mine, after which it is split into stopes and thence coursed through the intervening workings to the upcast shaft.

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> Entry to an end after blasting is not allowed until the whole of the air contained in the heading (measured from the face to the last through connection) has been replaced by fresh air.
>
> As an indication of the importance attached to the maintaining of healthy conditions underground, it may be mentioned that this mine employs 12 Europeans and over 200 natives entirely on ventilation and dust prevention work.
>
> It may safely be claimed that the reduction in the incidence of silicosis that has occurred during recent years is due, to a great extent, to the improved methods of ventilation and dust control described above, and it is probable that continued efforts in the same direction will improve the position still further.
>
> Whereas formerly a machine in a dead-end, without ventilation would produce a dustiness, which would give a count of 800 particles per centimeter in its own exhaust air, the drilling machine of to-day produces so little dust that the counts obtained in a sealed-off end are often lower than those of the air available for the ventilation of such ends.
>
> One of their recommendations was that where two machines are working in a drive a minimum of 800 c.f.m. should be blown in to dilute the dust. To be on the safe side one strives to introduce 1,000 c.f.m. of fresh air into every development end and double that amount for incline shafts. To replace the volume of a very long development end in a reasonable time will often require quantities that are in excess of the above.

An article on Heat in Mines in the August 30, 1930, issue of the South African Mining and Engineering Journal includes some interesting statements by South African inspectors about heat conditions in South African mines, among others that "17 deaths were recorded during the year (1929) from heat stroke. This figure does not by any means represent the sum total of the loss due to this cause." The following paragraph was taken from this article:

> Mr. Gray does not anticipate that relatively dry air can be secured in the workings except in exceptional cases. There must be humidity in the future as in the past. More careful acclimatisation of native workers, further adoption of labour-saving devices and arrangements, and increased and better-directed and concentrated ventilation currents will, so far as heat is concerned, permit of work continuing to considerably greater depths than at present reached.

Here again a South African governmental official indicates that ventilation is the real solution of the heat and silicosis problems in South African mines.

There were several other noteworthy contributions to the technical press concerning South African mine ventilation. In the March 22, 1930, issue of the South African Mining and Engineering Journal, under the title: "The Rand As A World Record Breaker," is a statement that -

> The largest mine-ventilation fan in the world is installed on the Rand. The fan in question is the 30-foot Walker fan at the Government Areas which is capable of exhausting 900,000 cubic feet of air per minute. The largest air compressor in the world is to be found at the Rosherville station of V.F.P., its capacity being 80,000 cubic feet of free air per minute.

The same journal, issue of April 26, 1930, publishes the following interesting statement:

> The very close and constant attention which the management is paying to ventilation accounts in no small measure for the facts that during the year under review the number of shifts lost owing to disease per 1,000 natives employed was about 35 per cent less than in the years immediately following the amalgamation. The ventilating appliances were augmented last year by a fan on the 19th level at No. 5 shaft and by various auxiliary fans in different parts of the mine. The latest ventilation measurements indicate that approximately one million cubic feet of fresh air are passed through the mine per minute, and with this quantity of air we are able to maintain reasonable working conditions in our bottom levels, where the rock temperature is over 95°F.

The Colliery Guardian of June 13, 1930, has an article on Influence on High Temperatures in Mines of The Rand; one of the most significant statements is the following:

> At extreme depth under present conditions there are two sureties, namely, high temperatures and high relative humidity, so that practically the only weapon of attack is movement of air. To obtain the greatest benefit from air movement, one must have adequate volume entering the mine, and exercise air concentration and control throughout the whole system.

MISCELLANEOUS ITEMS ON METAL-MINE VENTILATION

In Mining and Metallurgy for December, 1929, a short article descriptive of "Diamond Drilling and Air Injectors For Raise Ventilation" is worthy of being read, and at least some of the suggestions should be adopted. The conclusions of this article follow:

> The diamond-drill hole and the injector have made it possible to work raises for two or more successive shifts without danger from gases. The average cooling power in the raises has been raised from about 4.5 millicalories per sq. cm. per sec. to 7.0 and as much as 15 millicalories per sq. cm. per sec., depending largely on the source of air to the injector and the dryness of the diamond-drill hole. The average footage per day has been increased 40 per cent in raises ventilated by diamond-drill holes.

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(1) Regulation of the amount of compressed air used. It is not necessary to leave the air-valve open after blasting to clear the raise. The amount of compressed air used when not drilling, if any, is greatly decreased.

(2) Continuous and 'fool proof' ventilation. There are no repairs to be made, leaks to patch, motors to oil, etc. The ventilation is always at the top of the raise where it is needed. Manways are not obstructed by vent pipe, which is always broken and often not carried to the face in raises so ventilated.

(3) Raise free from gases. Increased efficiency and safety.

(4) Aid to raise alignment. The diamond-drill hole is used for raise lines, positively insuring good raise connections.

The cost of diamond-drilling varies greatly because of many factors such as condition of drilling, character of rock, length of holes, etc., so that any costs given here could not apply to other properties. The cost of compressed air, 20 cubic feet per minute, amounts to about $0.25 per 8-hour shift. Injectors cost about $15 complete with hose connections. Of the total cost approximately $0.50 per foot of advance can be charged to sampling, which is eliminated when the diamond-drill core is obtained.

The following paragraph from the August 8, 1930, Colliery Guardian indicates that ordinary types of compressed-air ventilation are unreliable at least where dangerous gases are to be removed and this is true whether in coal mines or in metal mines:

> The method of ventilating the faces of the levels and the immediately adjacent topholes by compressed air is no doubt much more convenient than the use of either bratticing or air pipes for this purpose. But, although there is nothing in the Coal Mines Act to preclude its use and, apparently, until the day of the explosion it had proved to be an adequate means of ventilation, it is not to be recommended. The supply, especially where, as in this case, quite a number of machines depend upon it for their motive power, is apt to be irregular and spasmodic. For this reason it is unreliable, and if firedamp is being emitted constantly, even if only slowly, a temporary cessation or interruption of the normal supply of compressed air is likely to result sooner or later in contamination of the atmosphere.

The November, 1929, issue of Heating Piping, and Air Conditioning had the following data in an article entitled "Drunk on Bad Air"; if the article gives a true picture it goes a long way toward explaining numerous hitherto unexplainable accidents in mines, but more particularly in metal mines where in far too many cases ventilation is looked upon as a fad:

> Throughout all tests the powers of concentration, steadiness, persistence, substitution, calculation, memory, and the ability to sustain continuous reaction ran such close parallels with increasing symptoms of asphyxiation that Mr. Johnson declares no distinction exists

between so-called "nervous" fatigue and physical exhaustion. Almost the entire range of disturbances observed relates to features in the physical environment, that is to say, to oxygen supply, air conditions, and comfort.

A man gets drunk on too low an oxygen intake. He is at first pleased, buoyant, and willing to continue set tasks indefinitely along the same lines of endeavor that have brought about his inherent "tiredness."

His attention narrows. He cannot be diverted from the thing that occupies him. He resents outside disturbance. He is unable to stop himself except by great endeavor.

He becomes dull, clumsy, slow to respond, stupid. He says silly things that give himself away. He winks and blinks and grins, and gets emotional flares out of situations that are extremely silly.

In advanced stages he begins to talk to himself. He converses with inanimate objects, reproaches a post or chair with tears or threats or curses. He may see double. His speech is thick. He is on a drunk, asphyxiated by the combustion products within his muscle cells.

Three conditions counterfeit this picture of alcoholic poisoning: (1) A diminished oxygen supply, due to great dilution of the air by means of other gases, or in rarefied air of high altitudes, or in inclosed spaces polluted by carbon monoxide; (2) a lowered rate of cell respiration caused by alcohol or other drug; and (3) induced fatigue, when cells burn faster than the toxic products of incomplete combustion can be washed away by the blood stream.